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B. T. GALLOWAY, *Chief of Bureau.*

COOPERATIVE GRAIN INVESTIGATIONS AT McPHERSON, KANS., 1904–1909.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., December 7, 1911.

Sir: I have the honor to transmit herewith a paper entitled "Cooperative Grain Investigations at McPherson, Kans., 1904–1909," by Mr. Victor L. Cory, Scientific Assistant in Grain Investigations, with an introduction by Mr. Mark Alfred Carleton, Cerealist in Charge of Grain Investigations, and recommend its publication as Bulletin No. 240 of the series of this Bureau.

The facts contained in this paper cover results obtained during the six-year period of 1904–1909 and therefore should be of sufficient extent to be of considerable value to farmers and others interested in the district to which these results are applicable. The experiments were conducted in cooperation with the Kansas Agricultural Experiment Station.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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B. P. I.—715.

COOPERATIVE GRAIN INVESTIGATIONS AT McPHERSON, KANS., 1904-1909.

INTRODUCTION.[1]

The investigations of grains with which this paper is concerned covered a period of 10 years in all, though during one of these years (1901) the work was suspended. The paper itself, however, discusses only the work of the years 1904–1909, as reports of the previous years are not sufficiently complete to be of value to the reader.

Experiments were begun at Halstead, Kans., in the autumn of 1899, with the chief aim at first to establish or develop varieties of wheat and other cereals resistant to rust and which would at the same time have the qualities of yield, etc., already present in the standard varieties then grown. The writer had already obtained several new varieties of wheat, oats, and barley from eastern and central Russia, some of which were very resistant to drought, and others resistant to rust, which varieties were employed, along with many other native varieties, in these experiments. Some 200 so-called different varieties of cereals were planted in nursery rows, and about one dozen tenth-acre plats were seeded with a few of the most promising winter wheats and spring-sown cereals.

In the spring of 1900 Mr. Deane B. Swingle was appointed special agent in direct charge of these experiments. During the summer about 200 different crosses were made among the wheat varieties of these experiments with the idea of combining yield, rust resistance, quality of grain, and winter hardiness. Several very hardy strains of the Crimean wheat were crossed with the very prolific variety Jones's Winter Fife. Durum wheats were used to give rust resistance to the standard winter varieties and the Zimmerman was crossed on the winter wheats to add earliness. Many of the resultant selections from the different hybrids thus produced are yet under experiment at different points in the country and some of them are likely to be important pure strains for the use of the farmer.

In the year 1901 the work in Kansas was interrupted but the seed obtained from the crosses the previous year was divided in the case of each cross into two equal portions and one portion in every case was

[1] The introduction has been written by Mr. Mark Alfred Carleton, Cerealist in Charge of the Office of Grain Investigations.

sown in the fall of 1900 at College Park, Md., where experiments had already been undertaken in cooperation with the Maryland Agricultural Experiment Station. In this way a year's time was saved in the continuation of the experiments with these hybrids, which would otherwise have been lost if there had been dependence upon the work in Kansas alone. In the fall of 1901 the other half of the seed of each original cross was planted at Halstead, Kans., and the experiments renewed at that place. A number of varieties of oats and barleys were also planted the following spring, but no crosses were made with these cereals. Additional varieties of winter wheat of considerable promise were planted at this time in tenth-acre plats and also several introduced varieties of oats and barley. Mr. Swingle having resigned to take a course of study in a university, Mr. L. A. Fitz was appointed as special agent in direct charge of the experiments, beginning in the spring of 1902. The experiments were continued during the summer of 1903, by which time considerable information had been obtained as to the adaptability of the varieties of hard winter wheat of the Crimean group, known locally in that region as Turkey wheat. Several new strains of this group obtained from south-central Russia appeared to be considerably better in hardiness and yield.

In the fall of 1903 the experiments were transferred from Halstead to McPherson, Kans. Meantime, Mr. Fitz having gone to another station, Mr. H. F. Blanchard was assigned to the direct charge of the experiments at McPherson. About this time arrangements were made for the Kansas Agricultural Experiment Station to take part in the experiments and since then the investigations have been in cooperation with that station. At the end of the crop year of 1905, Mr. Blanchard having been transferred to take charge of experiments in California, Mr. V. L. Cory was appointed as special agent in direct charge of the experiments and continued to conduct the work until it ended with the season of 1909.

Investigations were conducted at McPherson, Kans., for six continuous years and many things of much value to the farmers of the State were learned during this time. (1) It was demonstrated thoroughly that the varieties of winter wheat of the Crimean, or Turkey, group, which are widely grown in the State, are those best adapted to much the largest portion of Kansas. (2) It was learned at the same time that there is some difference in the various strains of this group of wheats and that apparently the Kharkof gives the best results for the winter-wheat area of the State as a whole, though in certain localities and certain seasons other strains may be at least as good or better.

Much information was obtained about winter emmer and winter barley, many varieties of which were grown during the time, permitting a very careful comparison of the adaptability of these varie-

ties. Much has been learned about buckwheat as a crop for that region and the wide difference in its varieties. A series of rotations of cereals with other crops was maintained, from which considerable information has been obtained. Seeding tests to determine the proper rate of seeding and the date of planting were conducted constantly and much has been learned as to methods of cultivation.

A considerable quantity of surplus seed has been produced each year for several years, which has been distributed throughout the State by the experiment station, through the persistent efforts of Prof. A. M. Ten Eyck, until recently in charge of the department of agronomy. As the region in which McPherson is situated is more nearly typical of the small-grain growing areas of the State than that around Manhattan, there is no doubt that much of the good resulting from distribution of seed of new strains of cereals adapted to Kansas has been derived from the work conducted at this point.

OBJECTS OF THE WORK.

The principal object of these investigations has been to find hardy prolific varieties or strains of wheat, oats, barley, and other small grains especially adapted to the conditions of central and western Kansas. Variety testing has been conducted extensively, and breeding and selection work has been employed to originate better types of grain and to improve the standard varieties. In addition an experiment in rotations was instituted in 1905 to demonstrate the inadvisability of growing one crop continuously on the land. The demonstration of the value of good preparation of the seed bed and the use of selected seed of the varieties best adapted to the conditions was of special importance locally. The distribution of seed of the best varieties has also been a feature of the work.

CONDITIONS INFLUENCING GRAIN YIELDS.

FIELD CONDITIONS.

The soil of the station farm is a deep, sandy loam of medium fertility. A portion of the field, about 2 or 3 acres, is low and not well drained. The entire field was badly infested with weeds when the experimental work was started, and as the smallness of the farm did not permit the use of a rotation of value for weed control no progress has been made in checking them. In consequence, the results are less valuable and the yields lower than would otherwise have been the case.

The most troublesome weed was the wild buckwheat (*Tiniaria convolvulus*). This is quite injurious in spring grains, but in the winter grains the fall growth covers the ground in early spring and

keeps it from getting started. It forms a mat or carpet on the ground, climbs up the stems of the grains, pulling down the plants and making them hard to harvest, and uses plant food and moisture greatly needed by the growing crops.

The low portion of the field is infested with *Gaertneria grayi*, locally termed "white ragweed," and occasionally with *Coreopsis tinctoria*, a tickseed locally known as wild flax. The former is an especially bad weed, and every plat containing a part of this low area was injuriously affected by it.

CLIMATIC CONDITIONS.

The mean annual temperature at McPherson is about 54.5° F. and the mean annual precipitation about 32.5 inches. The elevation is 1,495 feet. Killing frosts may occur as late as the first of May and as early as the last of September. No meteorological observations have been taken at the station; the data used in this report were obtained from the records of Mr. E. F. Haberlein, a voluntary observer, whose instruments are located 1 mile east of the station. The rainfall, by months, from August 1, 1903, to July 31, 1909, is shown in Table I. The totals for each crop year, which is here regarded as extending from August 1 to July 31 of the succeeding year, are also given.

TABLE I.—*Precipitation record at McPherson, Kans., from Aug. 1, 1903, to July 31, 1909.*

Month.	Year.						
	1903	1904	1905	1906	1907	1908	1909
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
January	.....	0.22	1.27	0.64	2.23	0.06	0.68
February	.....	.07	1.26	.28	1.34	.86	.81
March	.....	.67	2.17	2.60	1.87	.28	.46
April	.....	3.39	2.91	2.96	1.07	2.17	.93
May	.....	5.19	5.91	1.64	1.92	5.95	4.91
June	.....	8.77	5.02	6.00	4.23	9.27	6.64
July	.....	10.86	4.37	3.38	3.83	3.36	6.14
August	6.39	2.81	1.10	2.99	4.95	5.10	.....
September	5.28	5.14	6.33	4.30	1.15	2.65	.....
October	5.33	1.53	1.57	2.44	5.16	1.71	.....
November	1.24	.24	2.92	1.87	.62	2.19	.....
December	.36	.33	.12	1.16	1.76	.06	.....
January–July	.....	29.17	22.91	17.50	16.49	21.95	20.55
August–December	18.60	10.05	12.04	12.76	13.64	11.71	.....
Total for year	.....	39.22	34.95	30.26	30.13	33.66	.....
Total for crop year [1]	.....	47.77	32.96	29.54	29.25	35.59	32.26

[1] The crop year is regarded as extending from Aug. 1 of one year to July 31 of the succeeding year. Thus the rainfall for the crop year 1904 is the sum of the rainfall from Aug. 1 to Dec. 31, 1903, 18.60 inches, and from Jan. 1 to July 31, 1904, 29.17 inches, or a total of 47.77 inches.

The departure from the normal has been marked in but two of the years. In 1904 the rainfall was excessive, making it impossible to harvest a part of the grain properly and furthering a serious epidemic

of rust. In 1907 a fairly wet winter was associated with a comparatively high temperature. In April and May the weather was unusually cold, seriously checking the growth of the grain, materially damaging all the earlier varieties, and favoring a destructive invasion of the "green bug," or spring-grain aphis. While the rainfall has not been below 29 inches for any crop year, intervals of from three to six weeks of drought have occurred each year. These periods generally occur in early spring and late summer and have little effect on the crop. The dry winters have but little influence on the winter grains unless the season is unusually cold and windy. In the winter of 1908–9 this condition prevailed and caused quite a loss in the less hardy varieties.

GRAIN DISEASES.

Leaf rust has been present to a slight extent each year, but with the exception of 1904 it has not been abundant. In that year many of the oat varieties were badly affected by it, while the stem rust affected nearly all late varieties of small grain and in many cases caused entire failures. Emmer was severely attacked by the stem rust, while spelt was free from it, although it had considerable leaf rust. In succeeding years stem rust has attacked late varieties, especially emmer, but the injury has been comparatively slight.

In central Kansas the occurrence of smut in wheat, oats, and barley is universal. From personal observations in the surrounding country, not always based on actual counts, barley is believed to have a larger percentage of smut than oats and oats than wheat. Fields of barley have been noticed that were black with smut, with a loss of about 50 per cent. As only the tallest smutted stalks are seen in looking over a field, farmers are apt to overlook the presence of the disease. As an instance, on a near-by farm the farmer was questioned in regard to the presence of smut in his field of wheat. His statement that there was none was found upon investigation to be incorrect, for a small percentage of smutted heads was seen. Mr. Edward C. Johnson, pathologist in charge of cereal-disease work of the Bureau of Plant Industry, examined a few fields adjacent to the station for bunt, or stinking smut of wheat. In each case a small percentage was found, though this disease has not occurred on the station farm. The loose smuts are the prevalent ones, but the covered smut of barley is nearly as common as the loose smut.

INSECT ENEMIES.

The chinch bug and the wheat-straw worm have caused but slight damage in any of the years under discussion. In 1907 the spring-grain aphis, or "green bug," destroyed the durum wheat and with the

unfavorable climatic conditions caused practically a failure in all the other spring small grains. Winter wheat was damaged severely, but made a fair crop. The invasions of the spring-grain aphis, however, are very rare. Frequently serious damage is caused by the Hessian fly, which is distinctly a wheat insect, but occurs occasionally in barley and rye. The adult fly closely resembles a small mosquito, but does not feed, the injury to the plant being done by the larva in the form of a footless maggot. It is usually observed, however, in the pupa, or what is known as the "flaxseed" stage. It breeds twice a year, in the spring and in the fall, the spring generation remaining in the "flaxseed" stage throughout the summer and the fall generation throughout the winter. In the fall the adult flies emerge, chiefly in September and October, living long enough to mate and deposit eggs. The infestation of winter wheat may therefore be avoided by seeding at a date later than oviposition.

The time at which the seeding can be safely done varies with the latitude and the condition of the weather. Dry weather prolongs the "flaxseed" stage. For central Kansas a date as late as October 10 can be considered satisfactory. In 1905, when two sowings of three varieties of wheat were made, one about the middle of September and the other nearly a month later, the average yield of the early plantings was but 38 per cent of that of the late plantings, the difference of yield being largely due to the work of the Hessian fly. In but one other year, 1908, has the Hessian fly been the source of much loss. The damage then occurred just before harvest and was estimated at 15 or 20 per cent. The loss on the station farm was due to the surrounding infested fields, where the injury ran much higher. It is essential for farmers to act together in the use of clean cultural methods and comparatively late seeding for the control of this pest. The extensive loss which sometimes occurs in infested communities can be largely if not entirely prevented by united action.

VARIETY TESTS OF THE SMALL GRAINS.

WINTER WHEAT.

If the types of hybrids are considered as varieties, more than 1,200 varieties and strains have been tested, chiefly in rows, only 55 varieties having been grown in plats. The row plantings are sown with a garden drill in rows 12 inches apart and 33 feet long, with usually two rows of a variety. This is a very satisfactory method for testing varieties, as duplicate plantings have shown that the yields are approximately the same in both row and plat plantings and that any great difference can be accounted for satisfactorily. The plats used in the field tests of varieties were one-tenth of an acre each.

In Table II, 47 varieties which have been grown in plats for more than one year are listed. These are listed according to their average yield for the four years 1906, 1907, 1908, and 1909, but only 34 have comparable yields for each of these years. The remaining 13 varieties follow in the order indicated by their yields in the years when grown. The first column of average yields includes the comparable yields of the varieties in the preceding years of 1904 and 1905. All the figures represent actual yields from tenth-acre plats, except 1437 and 1559 in 1906, which are of acre plats. In 1905, 12 of the varieties were planted about the middle of September, while the remaining ones, with 3 which were included in the first planting, were planted about a month later. For the 3 varieties sown on both dates the average yield of the early planting was 7.78 bushels, and of the late planting 20.46 bushels per acre, or 2.63 times that of the early planting. Owing to this great difference, the yields from the early planting are not given, not being comparable. Along with these 9 varieties are 6 of the later plantings which, for other reasons, gave yields that are regarded as not comparable, thereby leaving only 24 out of the 39 varieties with comparable yields in that year. In the other years the yield is not given in a few cases where the results are known to be not comparable. Under the conditions prevailing on the station farm no system of check plats could be advantageously used.

TABLE II.—*Annual yields in bushels to the acre of varieties of winter wheat grown at McPherson, Kans., from 1904 to 1909, with the average yields for the entire period and for the four years 1906–1909.*

G. I. No.[1]	Name of variety.	1904	1905	1906	1907	1908	1909	Average.	
								General.	4-year.
1571	Turkey	.....	23.76	40.67	20.63	20.25	22.04	25.47	25.90
1583	Kharkof	26.54	(2)	36.21	20.63	19.13	22.13	24.93	24.53
1559	Crimean	26.58	(2)	[3] 37.93	23.63	15.79	18.17	24.42	23.88
1435	do	.....	21.90	37.83	22.17	17.29	18.13	23.46	23.86
1442	Kharkof	25.90	18.40	35.08	20.92	19.50	19.46	23.81	23.74
1539	Torgova	.....	23.80	34.17	17.38	16.67	20.96	22.60	22.30
1437	Crimean	23.66	(2)	[3] 33.74	21.83	14.46	17.75	22.29	21.95
1432	do	.....	19.34	36.04	18.71	16.46	[4] 15.88	21.29	21.77
1558	Turkey	35.33	(2)	34.79	13.50	17.79	20.50	24.38	21.65
1564	Pesterboden	18.75	(2)	36.30	17.50	14.17	[4] 17.46	20.84	21.36
1662	Roumanian	.....	(2)	35.54	16.92	14.08	20.46	.....	21.00
1543	Beloglina	.....	21.36	32.25	15.75	17.21	[4] 17.92	20.90	20.78
1560	Banat	20.17	(2)	31.13	16.38	17.00	[4] 18.25	20.59	20.69
1656	Roumanian	.....	25.90	35.33	15.09	11.67	[4] 20.46	21.09	20.64
1532	Red Russian	.....	23.25	31.58	16.13	17.96	16.71	21.13	20.60
1561	Theiss	24.00	(2)	29.75	17.46	16.17	18.96	21.27	20.59
1783	Oklahoma (hard)	.....	21.50	33.54	11.29	14.71	21.38	20.48	20.23
1439	Ulta	25.42	(2)	30.29	18.13	14.21	[4] 17.46	21.10	20.02
2908	Malakof	.....	.....	28.71	17.42	12.21	21.08	.....	19.86
1395–2	Diehl Mediterranean	.....	20.70	24.88	18.88	18.25	17.04	19.95	19.76
1756	Missouri	.....	18.86	33.88	14.54	12.75	[4] 17.42	19.49	19.65
1562	Bacska	22.23	(2)	30.46	13.50	16.00	[4] 18.38	20.11	19.59
1739	Budapest	.....	14.41	30.42	15.08	15.63	[4] 17.21	18.55	19.59
1658	Roumanian	.....	21.07	30.21	15.71	13.42	[4] 17.83	19.65	19.29
1355	Armavir	.....	21.70	29.38	19.46	12.54	[4] 15.38	19.69	19.19
1691	Bosnian Winter	.....	(2)	27.71	15.35	13.75	[4] 18.50	.....	18.83
1824	Zimmerman × Turkey	.....	.....	24.63	12.58	15.50	20.38	.....	18.27
1757	Japanese Velvet Chaff	.....	16.42	28.54	11.38	15.00	[4] 17.54	17.78	18.12

[1] Grain investigations number.
[2] Yields not comparable.
[3] Yield from acre plat.
[4] Discarded.

TABLE II.—*Annual yields in bushels to the acre of varieties of winter wheat grown at McPherson, Kans., from 1904 to 1909, with the average yields for the entire period and for the four years 1906–1909*—Continued.

G. I. No.	Name of variety.	1904	1905	1906	1907	1908	1909	Average.	
								General.	4-year.
2048	Bulgarian	.....	18.66	24.92	11.96	13.83	19.04	17.68	17.44
1784	Oklahoma (soft)	.....	19.77	30.13	8.83	16.33	[1] 14.17	17.85	17.37
2042	Hungarian	.....	24.22	25.00	10.00	13.04	20.33	18.52	17.09
2034	do	.....	26.75	23.96	10.59	14.33	[1] 18.29	18.77	16.77
2906	Currell	25.11	(2)	24.04	7.13	14.13	14.58	17.46	14.97
3010	Defiance	.....	.....	.....	.....	16.54	18.79	.....	.....
2907	Zimmerman	.....	.....	22.71	7.17	8.46	[1] 15.29	.....	13.41
1436	Crimean	23.50	(2)	32.17	18.67	[1] 11.54	.....	22.06	.....
1544	Beloglina	.....	20.77	32.17	12.88	[1] 14.67	.....	20.12	.....
1730	Servian	.....	.....	.....	(2)	12.63	17.21	.....	.....
1433	Crimean	.....	25.25	31.01	15.58	[1] 14.00	.....	21.46	.....
1676	Servian	.....	(2)	27.04	13.83	[1] 12.67	.....	.....	.....
1563	Weissenburg	26.63	(2)	30.92	13.13	[1] 10.29	.....	20.14	.....
3011	Eversole	.....	.....	.....	12.54	14.54	21.29	.....	.....
2979	Alberta Red	.....	.....	.....	.....	10.54	18.29	.....	.....
1788–1	Japanese Square-head	.....	19.74	25.71	[1] 8.25	.....	.....	.....	.....
1788–2	Japanese Velvet Chaff	.....	19.32	24.96	[1] 6.71	.....	.....	.....	.....
1787	Japanese	.....	18.65	22.04	[1] 8.50	.....	.....	.....	.....
	Number of plats	14	[3] 24	41	44	44	39	.....	.....
	Average yield	25.32	21.06	30.18	15.05	14.80	18.51	.....	.....

[1] Discarded.
[2] Yields not comparable.
[3] These yields are comparable for only 24 varieties, although 39 varieties were grown.

The leading variety in the four years for which comparable results are shown, 1906 to 1909, was the Turkey (G. I. No. 1571) with an average yield of 25.90 bushels to the acre. The next highest yielding variety was the Kharkof (G. I. No. 1583) with an average yield of 24.53 bushels. The other varieties which ranked among the first 10 were the Kharkof (G. I. No. 1442), the Crimean (G. I. Nos. 1432, 1435, 1437, and 1559), the Turkey (G. I. No. 1558), the Torgova (G. I. No. 1539), and the Pesterboden (G. I. No. 1564). With the exception of the Pesterboden these are all strains of hard red winter wheat from southern Russia[1]

[1] The sources from which these various strains were originally secured by the Bureau of Plant Industry were as follows:

G. I. No. 1432. Crimean. (Seed and Plant Introduction No. 6017.) From Kurman-Kemelchi, Russia. Received through Mr. M. A. Carleton, November, 1900.

G. I. No. 1435. Crimean. (S. P. I. No. 6015.) From Ambrocievka, Russia. Received through Mr. M. A. Carleton, November, 1900.

G. I. No. 1437. Crimean. (S. P. I. No. 5636.) From Altonau, near Melitopol, in northern Taurida, Russia. Received through Mr. M. A. Carleton, Dec. 12, 1900.

G. I. No. 1442. Kharkof. (S. P. I. No. 5641.) From Starobyelsk, Kharkof, Russia. Received through Mr. M. A. Carleton, Dec. 12, 1900.

G. I. No. 1539. Torgova. (S. P. I. No. 6007.) From Tsaritsyn, Russia. Received through Mr. M. A. Carleton, November, 1900.

G. I. No. 1558. Turkey. Obtained originally in the Crimea, but grown at Halstead, Kans., for some years before it was planted at McPherson.

G. I. No. 1559. Crimean. Imported in quantity of over 14,000 bushels from the Crimea in 1901, by the millers of Kansas and Oklahoma, through Messrs. B. Warkentin and M. A. Carleton.

G. I. No. 1564. Pesterboden. (S. P. I. No. 5500.) From Budapest, Austria-Hungary. Received Sept 27, 1900.

G. I. No. 1571. Turkey. Originally from the Crimea, but grown in Kansas and then in British Columbia before it was planted at McPherson.

G. I. No. 1583. Kharkof. (S. P. I. No. 7467.) From Kharkof, Russia. Received through Dr. A. Boenicke, Aug. 29, 1901.

More complete descriptions of S. P. I. Nos. 5636, 5641, 6007, 6015, and 6017 are to be found in Bulletin 66, Bureau of Plant Industry, U. S. Department of Agriculture, 1905.

and are of the type quite commonly grown in Kansas. The record made at this station shows the unquestioned superiority of this group of wheats for this region.

BARLEY.

Barley is but little grown in the vicinity of McPherson, and there is not much market for it. Its production value [1] per acre as a feeding crop indicates that it should be more largely grown in this section than it is at present. Some 200 varieties of barley have been tested, 31 of which have been grown in plats. The annual and average yields of these 31 varieties for the years when each was grown are shown in Table III.

TABLE III.—*Annual yields in bushels to the acre of 29 varieties of spring barley and 2 varieties of winter barley grown at McPherson, Kans., from 1904 to 1909, with average yields for the entire growth period of each variety and for the four years 1906–1909.*

G. I. No.	Name of variety.	Class.	1904	1905	1906	1907	1908	1909	Average.	
									General.	4-year.
	SPRING BARLEYS.									
90	Caucasian	Six-rowed	.....	.....	51.46	10.42	33.85	25.55	.....	30.32
205	Yenidje	do	.....	.....	51.77	4.79	32.45	25.26	.....	28.57
182	Odessa	do	.....	.....	44.48	9.95	30.47	27.08	.....	28.00
195	White Smyrna	Two-rowed	22.78	28.33	50.63	3.33	22.29	22.81	25.03	24.77
191	Black Smyrna	do	.....	.....	48.91	10.47	17.08	19.43	.....	23.97
184	Common	Six-rowed	.....	.....	36.20	5.78	28.23	[2] 21.67	.....	22.97
185	Baxters	do	.....	.....	33.07	4.06	26.82	[2] 24.22	.....	22.04
199	Albacete	do	.....	.....	45.42	9.11	16.77	[2] 16.41	.....	21.93
549	Common	do	.....	.....	40.94	4.11	25.42	[2] 15.78	.....	21.56
20	Perm	do	.....	.....	30.16	3.96	25.10	[2] 20.94	.....	20.04
181	Rennie's Improved	do	.....	.....	28.75	3.54	23.85	[2] 23.07	.....	19.80
237	Manchuria	do	.....	.....	35.16	4.69	15.26	23.59	.....	19.68
226	Hanna	Two-rowed	.....	20.00	40.73	.73	16.41	[2] 19.43	19.46	19.33
235	Manchuria	Six-rowed	.....	.....	31.15	5.63	14.11	[2] 25.21	.....	19.03
240	do	do	.....	.....	30.52	4.90	14.53	[2] 23.59	.....	18.39
212	Success	Hooded	.....	.....	27.31	1.98	18.28	[2] 17.97	.....	16.39
261	Marlout	Six-rowed	.....	.....	28.33	3.44	25.42	[2] 7.92	.....	16.28
507	Boehme's Beardless	Hooded	.....	.....	26.14	3.85	12.71	[2] 20.79	.....	15.87
211	Black Hull-less	Hull-less	.....	.....	31.75	2.13	15.75	[2] 11.88	.....	15.04
183	Nepean	Two-rowed	.....	.....	37.81	3.96	[2] 26.20	.....	22.66	.....
575	Gatami	Six-rowed	.....	.....	.....	.....	12.83	23.13	17.98	.....
263	(Garton Bros.)	do	22.35	5.25	32.19	2.50	[2] 4.90	.....	13.44	.....
190	Beldi	do	27.50	30.00	23.48	2.08	[2] 15.31	.....	23.67	.....
194	Telli	do	24.15	12.50	[2] 21.30	.....	.....	.....	19.32	.....
265	(Garton Bros.)	Two-rowed	25.90	6.00	31.35	([3])	.....	.....	15.81	.....
264	do	Six-rowed	20.22	5.25	29.69	.83	[2] 4.10	.....	12.02	.....
551	Common	Two-rowed	.....	.....	30.99	([3])	.....	.....	15.50	.....
210	Nepaul Hull-less	Hull-less	.....	.....	29.26	.63	[2] 15.59	.....	15.16	.....
266	(Garton Bros.)	Two-rowed	[2] 10.14	.....	.....	.....	.....	.....	10.14	.....
	WINTER BARLEYS.									
257	Tennessee Winter	Six-rowed	62.50	18.00	32.84	13.65	20.78	11.20	26.50	19.62
518	Maryland Winter	do	.....	.....	.....	12.08	24.17	10.42	15.56	.....
	Number of plats of spring barley		7	7	27	24	25	20	.....	.....
	Average yield		21.86	15.33	35.15	4.36	19.35	20.79	.....	.....

[1] The production value of a feed is determined by feeding it in addition to a basal maintenance ration—a ration simply maintaining the animal in a certain desirable condition—and is measured by the gain in flesh produced. The production value per acre is found by multiplying the yield of grain in pounds per acre by the production value of one pound. This method shows that, taking the average yields of the best varieties of each grain, barley ranks above emmer and oats, the other small-grain feeds.

[2] Variety discarded.

[3] Variety killed by late spring freeze.

As shown in Table III, three varieties,[1] Caucasian (G. I. No. 90), Yenidje (G. I. No. 205), and Odessa (G. I. No. 182), have yielded much higher than any of the others under test. The average yield of the Caucasian for the four years 1906–1909 was 30.32 bushels, of the Yenidje 28.57 bushels, and of the Odessa 28 bushels to the acre. These are all six-rowed bearded varieties in which the beards are almost wholly removed from the grain during thrashing. These varieties are recommended to the farmers in central Kansas. No other variety has averaged 25 bushels to the acre for this period. In the plat work at this station the two-rowed varieties which might otherwise have yielded well have been handicapped by their shortness of straw. Where these kinds will grow a sufficient length of straw they will yield equally as well as the common six-rowed barleys and the grain will be of a much better quality. It will be of heavier weight, superior plumpness and appearance, and entirely free from the objectionable beards usually present in the common varieties after thrashing.

Neither the Tennessee Winter nor the Maryland Winter barley has proved to be a success, though the former has made an excellent showing in other parts of the State. Neither the beardless nor the hull-less varieties, so far as tested, are adapted to this section.

OATS.

On account of the larger yield in bushels per acre and the greater ease in handling, oats are grown in this section to the practical exclusion of barley, which yields more in pounds per acre and is more valuable pound for pound from a feeding standpoint. In the plat work, as shown by Table IV, the yields of 33 varieties have been secured. A few other varieties have been grown, from which no yield was secured on account of destruction by rust or by winterkilling. In only one case has a fall-sown oat survived the winter and produced a crop. This was the Boswell Winter (G. I. No. 480) in 1908, when it gave the highest yield in the variety tests for that year. The following year it entirely winterkilled, but it is believed that this variety will prove a success as a winter oat. Other work in developing winter strains and in testing spring varieties is carried on in row plantings. Altogether some 200 varieties of oats have been tested. With the exception of Boswell Winter, all the varieties shown in the table were sown in the spring.

[1] These three varieties were originally received from the following:

G. I. No. 90. Caucasian. (S. P. I. No. 6023.) From North Caucasus, Russia. Obtained 30 miles east of Stavropol, Aug. 9, 1900, through Mr. M. A. Carleton.

G. I. No. 205. Yenidje. (S. P. I. No. 3677.) From Yenidje, near Brusa, Asiatic Turkey. Received through Mr. W. T. Swingle, July, 1899.

G. I. No. 182. Odessa. Received Mar. 17, 1902, from Indian Head, Saskatchewan, Canada.

TABLE IV.—*Annual yield in bushels to the acre of 33 varieties of oats grown at McPherson, Kans., from 1904 to 1909, with the average yield for the entire growth period of each variety, and for the four years, 1906–1909.*

G. I. No.	Name of variety.	1904	1905	1906	1907	1908	1909	Average.	
								General.	4-year.
165	Sixty-Day	44.88	33.75	43.52	4.70	49.06	52.97	38.13	37.56
337	Seventyfive-Day	.....	.....	[1] 51.00	4.92	39.45	50.78	.....	36.54
261	Georgia Rustproof	.....	.....	50.47	8.13	31.56	48.13	.....	34.57
260	Red Rustproof	.....	.....	51.02	3.44	35.08	48.28	.....	34.46
170	Perm	.....	.....	50.23	6.25	37.73	43.13	.....	34.34
256	Red Rustproof	.....	.....	46.56	6.02	33.44	50.16	.....	34.05
264	Mapstone	.....	.....	47.73	2.89	35.63	47.66	.....	33.48
236	Red Rustproof	.....	.....	48.67	4.45	33.59	[2] 43.83	.....	32.64
286	Red Algerian	29.36	[1] 30.72	42.03	5.31	37.11	44.45	31.49	32.23
226	Red Rustproof	.....	.....	45.55	2.11	38.13	[2] 39.77	.....	31.39
293	Burt	40.71	27.50	42.19	3.44	34.06	[2] 38.28	31.03	29.49
227	.....do	.....	.....	36.25	5.08	36.88	[2] 39.38	.....	29.40
228	.....do	.....	.....	35.16	5.39	38.75	36.88	.....	29.05
225	Calgary Gray	.....	.....	40.39	2.34	24.38	43.67	.....	27.70
244	Burt	.....	.....	30.63	3.83	34.38	[2] 40.00	.....	27.21
445	White Tatar	.....	36.88	44.17	4.69	23.36	[2] 34.92	28.80	26.79
230	Alaska	.....	.....	31.64	5.70	33.52	[2] 33.28	.....	26.04
243	Black Hussar	.....	.....	34.69	5.16	20.31	[2] 38.98	.....	24.79
219	Prince Edward Island	.....	.....	34.45	4.14	25.00	[2] 31.02	.....	23.65
444	Canadian	.....	28.75	37.27	3.59	16.25	[2] 33.05	23.78	22.54
441	Danish	.....	26.88	42.42	2.34	16.25	[2] 22.81	22.14	20.96
459	Kherson	.....	.....	[3]	6.72	41.17	49.92	32.60	.....
451	Red Rustproof	.....	37.50	[3]	5.55	36.95	46.41	31.60	.....
483	Shatilovsky	.....	.....	.....	.....	26.41	40.16	33.29	.....
480	Boswell Winter	.....	.....	.....	.....	50.55	[4]	25.28	.....
135	Tobolsk	8.75	16.25	42.81	1.02	[2] 12.31	.....	16.23	.....
213	Swedish Select	.....	29.50	39.77	1.48	[2] 11.49	.....	20.56	.....
509	Golden Rustproof	.....	.....	.....	.....	17.13	[2] 32.23	24.68	.....
481	Prolific	.....	.....	.....	.....	23.44	[2] 20.00	21.72	.....
443	Sparrowbill	.....	29.38	33.39	.78	[2] 5.25	.....	17.20	.....
442	Dun	.....	33.75	17.73	.....	[2] 1.09	.....	17.52	.....
486	(Unnamed)	.....	.....	.....	.....	7.65	[2] 14.30	10.98	.....
274	Snoma	.....	.....	[2] 17.27	.....	.....	.....	17.27	.....
	Number of plats	4	11	[5] 26	27	31	27	.....	.....
	Average yield	30.91	30.08	39.89	4.09	29.23	39.43	.....	.....

[1] Yield corrected, or average of 2 or more plats.
[2] Variety discarded.
[3] Yield not comparable.
[4] Winterkilled.
[5] 28 varieties grown.

The highest yield for the four years 1906 to 1909, as shown in the table, was secured from the Sixty-Day oat (G. I. No. 165), 37.56 bushels to the acre. Seventyfive-Day (G. I. No. 337), another oat of the same type, was second, with 36.54 bushels. Georgia Rustproof (G. I. No. 261) was third; Red Rustproof (G. I. No. 260) was fourth; and Perm (G. I. No. 170) was fifth.[1] The first, second, and fifth of these varieties are of the Sixty-Day type of oats. In 1906 the plats of No. 459 Kherson and No. 451 Red Rustproof were in a different part of the field and under better conditions. Their yields were higher than the other oats and if these yields were included

[1] The sources from which these varieties were originally obtained were as follows:

G. I. No. 165. Sixty-Day. (S. P. I. No. 5938.) From Proskurov, Podolia Government, Russia. Obtained through Mr. C. I. Mrozinski, of Proskurov, 1901.

G. I. No. 337. Seventyfive-Day. (S. P. I. No. 5168.) From Proskurov, Russia. Received through Mr. C. I. Mrozinski, of Proskurov, Russia, in 1900.

G. I. No. 261. Georgia Rustproof. Received Mar. 30, 1903, from M. W. Johnson Seed Co., Atlanta, Ga.

G. I. No. 260. Red Rustproof. Received Mar. 30, 1903, from M. W. Johnson Seed Co., Atlanta, Ga.

G. I. No. 170. Perm. (S. P. I. No. 538.) From Province of Perm, Russia. Received through Prof. N. E. Hansen, March, 1898.

it would place these two among the five leading varieties. The Kherson is of the Sixty-Day type, and for the three years 1907 to 1909 it was but slightly inferior to the Sixty-Day in point of yield. The types of oats best adapted to this locality are the Sixty-Day and the Red Rustproof.

OTHER GRAIN CROPS.

In addition to the testing of varieties of winter wheat, barley, and oats, similar work has been done with durum wheat, rye, emmer, spelt, einkorn, proso, nonirrigated rice, corn, and buckwheat. The yields produced by several varieties of durum wheat, spelt, emmer, einkorn, and winter rye are given in Table V.

TABLE V.—*Annual yield in bushels to the acre of several varieties of durum wheat, winter rye, emmer, spelt, and einkorn, grown at McPherson, Kans., from 1904 to 1909, with the average yields for the entire growth period of each variety and for the four years 1906–1909.*

G. I. No.	Name of variety.	1904	1905	1906	1907	1908	1909	Average.	
								General.	4-year.
	Durum wheat:								
2086	Pelissier	11.00	11.67	21.67	0.00	(1)	[2] 11.63	.....	.....
2094	Kubanka	12.67	11.25	25.63	.00	13.46	12.63	12.61	13.43
2100	Black Don	11.67	14.50	24.50	.00	(1)	13.42	.....	.....
2228	Saragolla	10.33	9.75	16.67	.....	(1)	[2] 10.88	.....	.....
2246	Kubanka	16.25	14.17	24.04	.00	(1)	13.83	.....	.....
	Winter rye:								
1	Russian	.....	.....	30.67	12.50	22.63	11.12	19.23	19.23
13	Do	.....	.....	29.87	11.02	27.28	12.90	20.27	20.27
34	Ivanov	.....	.....	32.95	12.36	20.80	10.31	19.11	19.11
34	Ivanov (Texas seed)	.....	.....	.....	19.81	26.47	12.81	19.70	.....
	Emmer:								
1522	Spring	.....	.....	30.83	1.83	[2] 5.25	.....	.....	.....
1527	Ufa Spring	.....	.....	24.44	1.30	[2] 6.15	.....	.....	.....
2337	Black Winter	.....	18.75	53.33	31.10	77.00	47.20	45.47	52.16
	Einkorn:								
1781	Winter	.....	7.94	32.68	[2] 7.15	.....	.....	.....	.....
2226	Do	.....	13.75	34.75	16.17	28.42	[2] .00	18.62	19.85
2433	Do	.....	11.17	35.04	[2] 3.83	.....	.....	.....	.....
1780	Spring	.....	.....	33.30	11.47	34.25	[2] 12.17	.....	22.80
	Spelt:								
1772	Red Winter	.....	33.44	49.20	35.60	60.00	42.40	44.13	46.80

[1] Record of yields lost; not more than 13.46 bushels. [2] Discarded.

The work with miscellaneous crops has not been extensive, but enough has been done to demonstrate that durum wheat, spring emmer, einkorn, and proso will not succeed in this locality.

The average yield of the Kubanka durum wheat for the four years 1906–1909 was 13.43 bushels to the acre, as compared with 25.90 bushels from the Turkey Winter wheat for the same period. The other varieties of durum wheat included in the test yielded about the same as the Kubanka. No spring wheat of any other type than the durum was grown.

The Black Winter emmer averaged 52.16 bushels to the acre for the four years 1906–1909, and the Red Winter spelt 46.80 bushels. Spring emmer and winter and spring einkorn produced much smaller yields of grain than the winter emmer and the winter spelt. These

grains are closely related to wheat, but the grain remains inclosed in the chaff and does not thrash out like wheat. Emmer and spelt are used for feeding live stock and compare favorably with oats and barley for that purpose. The large yields produced by the Black Winter emmer and the Red Winter spelt indicate that these grains may be of considerable value in central Kansas as producers of grain for feeding.

Winter rye has done very well. In the years 1907 and 1909, and possibly also in 1905, much damage to this crop resulted from a check to the growth at a critical period caused by unfavorable weather conditions after the crop was well advanced toward maturity. Where rye is grown for its yield of grain in this section it seems desirable to pasture it during the winter months in order to keep it from heading too early.

Proso has been a failure in all the trials. In 1909 a few varieties of nonirrigated rices were grown with promising results. Further tests are necessary before any recommendation can be made in regard to this crop.

Some variety testing has been done with corn, 23 varieties being grown in 1904 and 9 varieties in 1905. Since that time the work with corn has been confined to the rotation experiments. These tests showed that United States Plant-Breeding Selection 77 gave the best quality of corn; hence, this strain was grown in the rotation experiments instituted in 1905 and the testing of varieties was discontinued.

Fair results have been secured with buckwheat. Twelve or fifteen varieties have been tested in row plantings and three or four in plat plantings. A date-of-planting test, which included plantings in April, May, and the first half of June, indicated that the third and fourth weeks of April is the most favorable time for sowing buckwheat. It is possible that a date later than the middle of June may be found on further testing even better than the April plantings. The Sando Soba, a variety of the Japanese type, seems to be the best variety of those tested. The Chinese buckwheats are hardier and more drought resistant than are the other varieties, and generally they are longer in maturing. The small size and peculiar shape of the kernel of the Chinese buckwheats make them less attractive in appearance than the Japanese type. No information with regard to the comparative milling value of the different types was secured.

ROTATION EXPERIMENTS.

In 1905, 20 tenth-acre plats were set aside to test the effect of continuous cropping in comparison with alternate cropping of a small grain crop and corn. The original plan included the use of alfalfa and brome-grass in a rotation and the use of cowpeas and vetch as green-

manure crops, but these features were not completely carried out. The grains used in the continuous-cropping test were Tennessee Winter barley, Kharkof wheat, Sixty-Day oats, Red Rustproof oats, Ivanov rye, and Van Meter corn. To introduce the use of rye as a green-manure crop the continuous-cropping test of rye was abandoned. The results from the check plat in the alternate cropping of wheat and corn were made valueless by growing a crop of winter barley instead of wheat on it in 1906. With rye and wheat thus eliminated, the effect of continuous cropping was observed for the five years with but four grains, winter barley, corn, and two varieties of oats. While the period was too short to show very decisive results, the yields obtained favor the alternation of crops.

SMUT PREVENTION.

The loss occasioned by the grain smuts caused the institution of smut-treatment experiments on the station farm. The seed for the plat plantings in 1907 was treated with formalin, as follows: A solution was made by adding 1 pound of formalin to 50 gallons of water. The seed was suspended in a bag in this solution for 15 minutes or longer and then slowly dried. This treatment in most cases will prevent the stinking smut of wheat, the smut of oats, and the covered smut of barley. No appreciable diminution in the loose smuts in wheat or barley was noticeable, however, but there was no smut in the oats so treated. The next year all the wheats and barleys, including variety row tests, were given modified hot-water treatments, as follows: Wheat was soaked in cold water for 7 hours and then treated 15 minutes at 54° C.; barley was soaked in cold water 7 hours and then treated 15 minutes at 52° C.; and oats were treated 10 minutes in water at 57° C. without any previous soaking. In the crop following these treatments there was no loose smut in the wheat, only a trace of loose smut was in three of the varieties of barley, and there was no smut in the oats.

In the year 1909 no smut treatments were given and, with the exception of the durum wheats and winter barleys, smut was present in all the grains and in nearly all the varieties. This was undoubtedly due to infection of the grain at flowering time the preceding year, when loose-smut spores were blown from adjoining smutty fields to the station fields.

From the experience with the various smut treatments the following conclusions are drawn: (1) Loss from oat smut may easily be prevented by the formalin treatment, which is simple, effective, and inexpensive. (2) The modified hot-water treatment [1] is successful in

[1] A full description of the hot-water treatment for the loose smuts of barley and wheat is contained in Bulletin 152, Bureau of Plant Industry, U. S. Department of Agriculture.

preventing the loose smuts of wheat and barley. (3) Where surrounded by smutted fields, treatment of the seed each year is necessary to insure absolute freedom from smut.

SUMMARY.

Experiments with cereals were conducted at McPherson, Kans., from 1904 to 1909 by the Office of Grain Investigations of the Bureau of Plant Industry in cooperation with the Kansas Agricultural Experiment Station.

The leading object of the work was to determine the two or three best varieties of each of the grains for the wheat belt of the State and to introduce these superior varieties on the farms throughout the section.

Other objects of the work were to originate better types of grain and improved strains of the best standard varieties, to demonstrate the importance of good seed-bed preparation in connection with the use of good seed, and to show the inadvisability of the continuous growing of a single crop.

The conditions were not very favorable for experimental work, as a part of the field was not well drained and all of it was badly infested with weeds.

The mean annual rainfall at McPherson is 32.5 inches. There was no serious drought during the period covered by the experiments.

With the exception of the year 1904 rust did not seriously damage any of the crops.

Smut was almost universally present and caused great damage.

The invasion in 1907 of the "green bug" (*Toxoptera graminum* Rond.) was very destructive, but the invasions of this insect are very rare.

In 1905 and again in 1908 the Hessian fly caused great loss, showing the need of cooperation among grain growers in later fall seeding and clean cultural methods to keep this insect in check.

Three varieties of hard winter wheat from Russia, the Turkey, the Kharkof, and the Crimean, gave the highest yields and are recommended for general planting.

The best yielding barleys, the Caucasian, the Odessa, and the Yenidje, are all six-rowed bearded varieties. The winter barleys tested produced much lower yields than the best spring varieties.

The Sixty-Day and the Red Rustproof are the two types of oats best adapted to this section.

Durum wheats, spring emmer, spring spelt, einkorn, and proso did not prove to be profitable grain crops in this section. Winter emmer and winter spelt yielded well and good crops of winter rye were produced. A single year's trial of nonirrigated rice shows it to be worthy of further testing.

No extensive variety testing of corn has been carried on, but in the rotation experiments it has proved to be a very satisfactory crop from the crop-value standpoint.

Buckwheat has not been extensively tested. From the results which were obtained, however, the best varieties seem to be of the Japanese type. Early planting gave the highest yields.

The rotation experiments were not conducted long enough to make the results reliable or to secure the full benefit of the rotations, but alternation of crops produced higher yields than the continuous growing of a single crop.

Experiments in the treatment of small grains for smut showed that oat smut can be controlled by the formalin treatment, while the hot-water treatment was a success in preventing the loose smuts of barley and wheat.

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